

Can Alcohol-Based Hand-Rub Solutions Cause You To Lose Your Driver's License? Comparative Cutaneous Absorption of Various Alcohols[▽]

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Received 23 October 2006/Returned for modification 22 November 2006/Accepted 17 December 2006

We assessed cutaneous ethanol (ETOH) and isopropanol (ISOP) absorption after intensive (30 times per h) use of alcohol-based hand-rub solutions by healthcare workers (HCWs). ETOH was detectable in the breath of 6/20 HCWs (0.001 to 0.0025%) at 1 to 2 min postexposure and in the serum of 2/20 HCWs at 5 to 7 min postexposure. Serum ISOP levels were unrecordable at all time points.

Although hand hygiene culture-change programs using alcohol-based hand-rub solutions (ABHRS) have been associated with a reductions in nosocomial infections, some health care workers (HCWs) remain concerned about potential cutaneous absorption of alcohol from ABHRS (1, 4, 10, 11, 13). In particular, some young HCWs who are required to have a zero serum alcohol level to legally drive automobiles (probationary license) and HCWs of Islamic faith may have reservations about their exposure to alcohol (1, 13). Thus, we aimed to assess the cutaneous absorption of the two most commonly used alcohols (ethanol [ETOH] and isopropanol [ISOP]) among HCWs who used ABHRS intensely (13).

(Presented in part at the 47th Interscience Conference on Antimicrobial Agents and Chemotherapy, San Francisco, CA, September 2006).

Consenting HCW volunteers completed a questionnaire recording their age, height, weight, gender, ethnicity, alcohol consumption during the 24 h prior to the study, and prescribed medication usage. Participants' heights and weights were used to calculate their body mass indexes (BMI). HCWs were excluded if they had a evidence of chronic dermatitis (e.g., eczema) or broken/damaged skin or a history of allergy to ABHRS or were currently pregnant.

We assessed two commonly used ABHRS that contained 0.5% chlorhexidine gluconate, a skin emollient and either 70% ETOH (Avagard; 3M Healthcare, Pymble, Australia) or 70% ISOP (DeBug; Orion Laboratories Pty Ltd., Balcatta, Australia) (4, 13). To mimic intensive clinical conditions, HCWs used ABHRS 30 times during a 1-h period on two separate days, with a 1 day "washout" period between (day 1, Avagard use; day 2, washout; day 3, DeBug use). Supervisors coordinated, timed, and advised all participants when to reapply ABHRS and ensured compliance with the correct application (one

squirt [1.2 to 1.5 ml] every 2 min) of ABHRS (13). Study room conditions were as follows: room temperature, 24 to 26°C; humidity, 39 to 42%; study room volume, 124 cubic meters.

Breath and serum alcohol levels were assessed as follows. Preexposure (baseline), breath and serum alcohol levels were assessed. Postexposure (time after last application of ABHRS), at 1 to 2 min, breath levels only were tested; at 5 to 7 min, serum levels only were tested; and 10 to 13 min, breath levels only were tested. Breath alcohol levels were assessed by police from the Traffic Alcohol Section, Victoria Police, using a Dräger Alcotest 7110 breathalyzer (lower limit of detection, 0.001%), as is used by Victoria Police for all evidential breath alcohol analysis, following preliminary roadside breath testing using a hand-held screening device. Results from this breathalyzer are sufficiently accurate to be legally admissible in court and obviate the need for serum ETOH assessment. The breathalyzer detects ETOH but not ISOP. All breathalyzer analyses were undertaken in a room distant from where ABHRS was in use to avoid potential vapor contamination of breath alcohol tests.

Serum ETOH and ISOP levels were assessed by gas chromatography (lower limit of quantitation, 0.002 g/100 ml [%]; lower limit of detection: 0.0001 g/100 ml [%] for both alcohols) at the Victorian Institute of Forensic Medicine, where all serum/blood alcohol assessments are undertaken for the State Coroner of Victoria. Serum specimens were collected in routine sodium fluoride/EDTA venipuncture tubes and stored at 4°C until analysis. Alcohol-containing skin cleansers were not used to swab the skin before venipuncture. The study protocol was approved by our institution's Human Ethics Committee.

Twenty HCWs (mean age, 40 ± 13 years [median, 36 years; range, 22 to 67 years]; 14 females; ethnic distribution, 18 Caucasian, 2 Asian) participated in the study. Participants' mean BMI was 26 ± 4 (median, 24; range, 21 to 34; acceptable BMI, $n = 11$; overweight BMI, $n = 4$; obese BMI, $n = 5$) (6). One HCW, who regularly used DeBug without any adverse reactions prior to this study, developed a severe cutaneous reaction to Avagard after day 1 such that she could not participate on day 3. Thus, 20 HCWs completed use of Avagard and 19 used DeBug in the study. Both ABHRS groups were sampled at

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[▽] Published ahead of print on 28 December 2006.

TABLE 1. Breath and serum alcohol levels before and after intensive use of alcohol-based hand-rub solution

Time and type of specimen	No. of HCWs with detectable alcohol levels/total no. of HCWs	
	Ethanol (n = 20)	Isopropanol (n = 19)
Preexposure (baseline)		
Breath	0/20	NA ^a
Serum	0/20	0/19
Postexposure		
1–2 min, breath	6/20 ^b	NA
5–7 min, serum	2/20 ^{c,d}	0/19 ^d
10–13 min, breath	0/20	NA

^a NA, not assessable by Drager Alcotest 7110 breathalyzer.

^b Specific levels for these six HCWs were 0.0010%, 0.0012%, 0.0014%, 0.0014%, 0.0018%, and 0.0025%.

^c Specific levels for these two HCWs were 0.0006% and 0.0015%.

^d No statistical difference between 2/20 versus 0/19 HCWs ($P = 0.49$, Fisher's exact test).

similar times postexposure (mean \pm standard deviation minutes after last application: ETOH, 2.3 ± 1.2 , 6.4 ± 1.6 , and 13.4 ± 1.7 ; ISOP, 1.9 ± 1.2 , 7.1 ± 1.6 , and 12.0 ± 1.7).

Results are shown in Table 1. ETOH levels were detectable in breath analysis of 6 of the 20 HCWs (range, 0.0010% to 0.0025%) at 1 to 2 min after the final application of Avagard: all would have been recorded as undetectable by Victoria Police performing routine roadside breathalyzer testing. However, two of these six HCWs also had detectable serum ETOH levels at 5 to 7 min postexposure. All breath ETOH levels were zero at 10 to 13 min after Avagard use. Measurable ETOH levels were not associated with HCW age, sex, ethnicity, or BMI, but statistical power was limited due to the low number of participants with detectable levels. All serum ISOP levels were unrecordable at each time point.

This study mimicked clinical settings in which intensive use of ABHRS of up to 30 times per h is required, such as in intensive care units (4, 10). We limited our study to a 1-h duration, since after such periods of intense activity, HCWs frequently wash their hands in soap and water because they have eventually become visibly soiled or because they take a break from clinical activity (2, 4, 10). Unlike one recent case report (5), our study demonstrates that very small amounts of ETOH may be absorbed during intensive use, either via transcutaneous absorption or inhalation of fumes in closed areas. However, none of these levels would be considered positive during either a routine or evidential police breath alcohol test. In comparison, no detectable serum ISOP absorption could be detected during this study.

Our findings appear to differ from those of Turner et al. who detected small levels of ISOP (0.5 to 1.8 mg/liter) in 9 of 10 participants after using ABHRS six times per h for 4 h (11). However, the assay they used had a lower limit of detection of 0.0005% (one dilution more sensitive than our assay) and a number of their participants had very low ISOP levels (0.0005% to 0.001%). Secondly, they applied a larger volume (3 ml) of 52.6% ISOP-containing ABHRS and did not wash their hands with soap and water for >4 h.

Our study has some limitations. First, since 9/20 HCWs were

either overweight or obese, we cannot be sure whether lower-body-weight HCWs might not have higher levels. Secondly, we did not assess the routine alcohol consumption of our HCWs and therefore cannot be certain of the impact of increased alcohol metabolism on serum levels. Finally, we cannot be sure that intensive ABHRS use for longer than 1 h without washing may not result in higher absorption or accumulation rates (4, 10, 13).

Although there are many reasons described by HCWs regarding why they exhibit poor hand hygiene compliance (3, 7, 8, 9, 12), fear of alcohol absorption and loss of one's drivers license is no longer valid. Since ISOP appears slightly more predictable in its lack of cutaneous absorption than ETOH, ISOP-containing ABHRS may be preferred by some HCWs and religious groups.

We gratefully acknowledge the enthusiastic support of Marie O'Brien and the 20 Austin Health HCWs and medical students who participated in this study, Senior Constable Ian McGrath and Forensic Officer John Papavasiliou from Victoria Police who assisted with the alcohol breathalyzer testing, and Nonie Bridgland and Kylie King from Austin Health Pathology who performed all venipunctures.

There are no conflicts of interest. However, DeBug (a trademark for one of the hand hygiene product referred to in this article) was developed by some of the authors (employees of Austin Health) with funding in part from the Department of Human Services, Victoria, Australia. The intellectual property for this development is held by Austin Health, which handles all patent, trademark, and licensing issues. Austin Health, but no individual author, receives a small income stream from the sale of DeBug.

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